



UNDERSTANDING AND ADDRESSING THE IMPACT OF AIR POLLUTION ON CHILDREN'S HEALTH IN MONGOLIA



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This is a working document. It has been prepared to facilitate the exchange of knowledge and to stimulate discussion. The findings, interpretations and conclusions expressed in this paper are those of the authors and do not necessarily reflect the policies or views of UNICEF or of the United Nations.

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Appendixes 1, 2 and 3 of the report are drawn from the rapid assessment performed by Enkhjargal Altangerel and Agni Baljinnyam of the Mongolian Public Health Professionals Association.

This report is part of the project on "Children and Environmental Change in Mongolia" implemented by UNICEF Mongolia with the aim of addressing air pollution-related health impacts on children living in Ulaanbaatar and helping to develop mitigation measures.

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FOREWORD

Air pollution is an increasing problem for children in East Asia and the Pacific, due in part to rapid urbanisation and slash-and-burn farming. It has become so bad that an 'Asian brown cloud' can now be seen from space around January to March every year. This is very harmful for children – it affects their health and development. In the worst cases, respiratory infections can be life threatening.

With its vast open spaces and semi-nomadic population, Mongolia might not seem like an obvious place for air pollution. However, Ulaanbaatar is actually one of the worst affected cities in the region. This is because of the harsh winter climate and vast 'ger district', where people live in tents and burn coal to stay warm – a traditional lifestyle that works in the countryside but not in a dense urban environment.

Protecting children from the effects of climate change and environmental degradation is an important priority for UNICEF, in line with our mandate to protect the rights of all children, especially the most vulnerable. It is also a pillar of the new UN Sustainable Development Goals (SDGs). If we are to meet these goals, environmental degradation must be addressed and this starts with children and adolescents. They will inherit a planet that today is severely affected by uncontrolled use of resources and the harmful effects of soil, water and air pollution.

The global reality is frightening and it urges us to act quickly and decisively. Currently, more than half the world's population live in urban areas. By 2050 this is expected to reach 70 per cent. Globally, indoor air pollution contributes to 4.3 million deaths each year. More than half a million of these deaths are children under five years old, with over 50 percent due to pneumonia caused by air pollution.

All of this is particularly true in East Asia and the Pacific, a region known for the remarkable economic growth achieved in the past 20 years. Together with population growth, this presents new opportunities for the future, but also puts increasing pressure on an already fragile environment.

China, for example, has seen important progress in addressing environmental challenges but people in its growing urban areas are regularly exposed to the highest levels of air pollution. In Indonesia and Malaysia, smoke from agricultural burning has disrupted schooling and caused concern for children's health. Everywhere in this fast growing region, the environment is strained and children are exposed to the effects of rapid industrialization and urbanization.

Mongolia is not free from these challenges, despite being a country known for its stunning beauty and unique landscape of uncontaminated land and sky. Rapid and unplanned urbanization have made Ulaanbaatar one of the most polluted capitals in the world. For this reason, UNICEF's engagement in understanding the effect of air pollution on children is particularly timely and crucial.

This report takes stock of important scientific evidence, in order to make a compelling call for action. It recently informed an international expert consultation in Mongolia on Air Pollution and Children's Health. The research is also evidence of UNICEF's commitment to tackling climate change and environmental degradation as one of its programming priorities, not just in Mongolia but globally.

UNICEF aims to integrate environmental sustainability throughout our programming work. We are advocating for recognition and inclusion of children in discussions about environmental sustainability. And we are seeking to include environmental considerations in public and private finance, which will benefit children's development and well-being.

I believe that improvements are possible. Recently, governments have shown the ability to move towards concrete results, shaping new policy agendas and mobilizing budgetary resources. Mongolia can be an example to other countries in leveraging political will and civil commitment to address air pollution effectively. I am confident that this report will be a compelling tool to accelerate action and help Mongolian children inherit a country that is greener and more sustainable than today.



Karin Hulshof, Regional Director, UNICEF East Asia and the Pacific

A CALL FOR ACTION FOR MONGOLIA

The alarming levels of air pollution in Ulaanbaatar during the long winter cannot be neglected any longer as their short and long-term negative health impact has been demonstrated especially for children. It is around this indisputable fact that UNICEF Mongolia has taken environment sustainability as one of its program priorities, in close cooperation with the Mongolian Government and national partners. As a result, UNICEF Mongolia focused on generating evidence to raise public awareness on the impact of air pollution on child health and to contribute to the development of mitigation measures. This research paper was therefore intended as a tool to present compelling scientific evidence on the most severe consequences of the continued exposure to high level of air pollution of Mongolian children.

This analysis was instrumental to inform an international expert consultation on “Air Pollution and Children’s Health” that was held in January 2016 with high level international and national experts with the aim to identify policy solutions to tackle negative effects of pollution on children. Its recommendations were presented to both the Mongolian Parliament and Government and represent today a viable platform of action for decision makers.

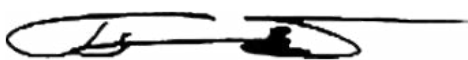
With a new Government in place, supported by a vast consensus after the elections of July 2016, there is now a renewed opportunity to translate these commitments into concrete actions. This has to start with the protection of children and adolescents’ health from air pollution as an immediate priority. Only by doing this it will be possible to avert the risk of a veritable public health crisis in the coming years, with air pollution already contributing to deaths from pneumonia in young infants, and lung damage that affects the health and well-being of children throughout the rest of their lives. Today we know that current exposures of children to air pollution have not been experienced by previous generations and children are projected to suffer from unprecedented levels of chronic respiratory disease later in life. The economic costs of these disease burdens will continue to increase over the next decade unless major new measures are taken urgently.

UNICEF’s new Country Programme of Cooperation with the Government of Mongolia for the period 2017-2021 has embraced environmental sustainability, climate change and air pollution as one of its programmatic components. Close cooperation with the Ministry of Environment, Ministry of Health and the Public Health Institute will continue with focus on pneumonia prevention, improved monitoring of air pollution through adolescents’ participation and continued knowledge generation on health impacts.

Sound interventions are always built on reliable evidence and we are confident that this paper can provide a ground of compelling reasons to act urgently on addressing the impact of air pollution on children in Mongolia. In a country where children are a third of its population and young generations represent its most valuable resource, focusing on environmental sustainability is not only morally imperative, but it is also a smartest choice to ensure long term sustainable development. What is at stake is not only children’s right to live a healthy life and reach their full potential, but Mongolia’s own human capital and chances of a prosperous and green future.



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Acronyms

ALRI	acute lower respiratory infection
CNG	compressed natural gas
DALY	disability-adjusted life year
DME	dimethyl ether
GDP	gross domestic product
HEPA	high-efficiency particulate air
HIV	human immunodeficiency virus
HVAC	heating, ventilation, and air conditioning
LNG	liquid natural gas
LPG	liquid petroleum gas
MCA	Millennium Challenge Account
PM _{2.5}	particulate matter with an aerodynamic diameter of less than 2.5 µm at the fiftieth percentile cut-off
RSV	respiratory syncytial virus
SNG	synthetic natural gas
WHO	World Health Organization

EXECUTIVE SUMMARY

Ulaanbaatar is not only the coldest capital of the world, but it has also some of the worst outdoor air pollution levels during its long winter, resulting in short and long-term health effects on its population. As children are some of the most vulnerable population groups and constitute a large part of Mongolian society, the magnitude of these effects is disproportionately higher on the youngest generations, unless concrete mitigation efforts are in place.

As part of UNICEF's commitment to strengthen the child focus in policy and public discussion on air pollution in Mongolia and to support the development of pro-child mitigation measures, this working paper was produced to gather compelling scientific evidence on the impacts of children's exposure to Ulaanbaatar's high levels of pollution. This includes young infant deaths from pneumonia, lung damage, reduced fetal growth, preterm birth as well as other short and long-term effects. The three diseases that resulted in the most lost life years in Mongolia in 2013 were air pollution-related, indicating the urgency of identify sustainable responses. In particular, the paper presents evidence of exposure to air pollution during vulnerable periods of children's development with a lasting impact on health. Children's lungs develop throughout childhood, but are critically vulnerable in the neonatal period. Lowering young infants' exposures to outdoor and indoor air pollution is therefore particularly important in order to reduce pneumonia and the impact on lung development. Similar measures should also be taken to reduce exposures in school-age children.

The paper also identifies a set of integrated policy approaches and concrete interventions that could reduce this disease burden, referring to a platform of recommendations that emerged from an international expert consultation organized on this subject. To decrease the incidence of air pollution-related disease on children in Ulaanbaatar, the report identifies three priorities to be addressed:

- Switching to clean fuels in homes and schools and increasing the coverage of district heating, to reduce exposures to air pollution.

- Increasing the coverage of vaccination and treatment in community care centers to reduce the incidence of pneumonia.
- Tackling risk factors for air pollution-related disease, including exposure to tobacco smoke, undernutrition, and lack of exclusive breastfeeding.

While Government and international agencies clearly acknowledge the need to switch to clean fuels, a priority now is to increase their awareness of the economic benefits of investing in intervention strategies quickly rather than more gradually, and of the burdens imposed by inaction on air pollution. Another priority is to develop a coordinated strategic master plan across stakeholders to tackle air pollution in Ulaanbaatar. Coordination and communication between ministries and with international agencies will become increasingly important, particularly in relation to building codes, energy efficiency, energy subsidies and new technologies.

A range of practical actions is also needed on the ground, starting with the definition of clear institutional accountability levels and mechanisms for coordination at both central and local level. These actions should particularly focus on the environments in which children are exposed to air pollution and specifically on prenatal care and the first year of life, as well as indoors at home and at school.

During prenatal care and the first year of life, interventions should focus on reducing exposure to tobacco smoke, increasing coverage of pneumococcal vaccines, building capacity of community care centers to treat pneumonia infections using antibiotics, as well as immunoprophylaxis with palivizumab (monoclonal antibody) against respiratory syncytial virus (RSV) in high risk children. In addition, increasing exclusive breastfeeding in the first six months is indicated as a key priority as well as addressing current nutritional deficiencies.

Physical mitigation measures are equally important and this should include adding mechanical air pollution filters to maternal and child care programs to reduce indoor air pollution

concentrations at home and exposures during pregnancy and the first year of life. In homes, interventions should focus on the shift from coal to gas fuels, combined with connecting more central buildings to district heating. Other measures include standardizing and increasing home insulation, supplying permeability barriers and installing vestibules in both houses and gers to improve energy efficiency and decrease the penetration efficiency of ambient pollution indoors. Furthermore, reducing exposure to tobacco smoke at home is an utmost priority. In schools, replacing coal-fired boilers for central heating with gas furnaces will both reduce coal consumption and decrease emissions into the immediate environment where children spend a significant amount of time. Where schools are equipped with HVAC systems, HEPA filters should be installed in air ducts to reduce indoor air concentrations.

Behavioral change and awareness raising are two other critical areas of interventions suggested by this research. Schools provide a critical environment for disseminating messages about air pollution, the need for clean fuels, and health impacts, which children could take home to parents in ger areas, if this information was incorporated into curricula. School curricula can play an important role in awareness-building, social accountability and mobilization.

Today, Mongolian children are seriously affected by air pollution and the report urges for immediate action, in addition to measures already implemented by the Government of Mongolia. Reducing the effect of air pollution on children needs political commitment to ensure sufficient resources are allocated for research into its health impacts, adopting an effective regulatory framework, as well as to evaluate the impact of policies on air quality.

The Government of Mongolia has taken air pollution as an important priority and much progress has been made already. The report adds the specific child focused angle to support accelerated implementation of these plans and policies and ensure that children remain at the core of any measure to mitigate and ultimately eliminate the impact of air pollution on the health of all Mongolians.



PART 1: THE HEALTH IMPACTS OF AIR POLLUTION ON CHILDREN IN ULAANBAATAR

INTRODUCTION

Ulaanbaatar is today one of the most polluted cities in the world. Air pollution has now reached critical levels, with city residents exposed to annual average concentrations of fine particulate matter (PM_{2.5}) over seven times higher than World Health Organization (WHO) international guidelines,^{1,2} and over three times higher than annual average Mongolian national standard of 25µg/m³ (see Appendix 1). Unless concrete efforts are made to address this situation, exposures will gradually increase over the next 10 years with significant health consequences for the city's population.³ Although Article 5.2 of the Mongolian Law on Child Rights (1996) guarantees children the right to grow up healthy and to live in a safe environment, this is far from a reality for Ulaanbaatar's youngest citizens.

The objectives of this working paper are to document the main environments in Ulaanbaatar where children are exposed to air pollution during critical periods of their development and - based on existing literature - gather compelling evidence on the consequences of that exposure in later life. In addition, the paper aims to highlight the importance of preventing this exposure and it identifies a suite of integrated policy approaches and interventions on the ground to reduce disease burdens.

Air pollution in Ulaanbaatar is caused by a combination of high emissions and its unique geography and climate. The city, which lies in a valley surrounded by mountains, has grown rapidly, with an influx of people from rural areas looking for better opportunities for themselves and their families. They settle on the outskirts, often bringing their *gers* (traditional circular felted tents) covering the hills surrounding Ulaanbaatar. These outskirts are known as the *ger* districts, although 60 per cent of dwellings are single and two-storey homes. With limited access to basic

social services, people in *ger* districts rely on coal-burning stoves to heat their homes continuously throughout the bitterly cold winter months (October–March), when temperatures drop as low as -40°C.

This is the source of much of Ulaanbaatar's pollution, with 70 per cent of PM_{2.5} in the *ger* districts coming from such stoves,^{4,5} although power plants, vehicles, and industry also play a role. Since heating stoves contribute to most of the emissions, air pollution concentrations show a marked diurnal pattern, with high peaks in the evening until midnight and in the early morning. As well as damaging health, fuel costs are a substantial economic burden, accounting for up to 40 per cent of household income in the poorest wealth quintile.⁶

This situation is exacerbated by the city's position, in a valley surrounded by mountains, and by its climate. Ulaanbaatar's winter weather is strongly affected by the mid-continental Siberian anticyclone, which leads to a weather phenomenon known as a temperature inversion, where a layer of cool air on the ground is covered by a layer of warm air, effectively trapping pollutants in the city at the bottom of the valley.

Children are among the most vulnerable to the impact of air pollution. Air pollution-related disease poses a high mortality risk for infants and young children, with an estimated 230,000 deaths per year globally from pneumonia as an acute lower respiratory infection (ALRI), caused by outdoor air pollution,⁷ in addition to more than 500,000 deaths per year caused by household air pollution through the use of solid fuels for cooking.⁸ Household pollution from heating with solid fuels causes further mortality, but this has not yet been

⁴ Allen et al., op.cit.

⁵ World Bank Asia Sustainable and Alternative Energy Program (ASTAE) Mongolia, 'Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar', <http://iteresources.worldbank.org/INTMONGOLIA/Resources/Mongolia_heating_poor_peri_urban_ger_areas_of_UB_ASTAE_ENG.pdf>.

⁶ Social Impact 'Impact evaluation results of the MCA Mongolia Energy and Environment Project Energy-Efficient Stove Subsidy Program', Arlington, VA; 2014.

⁷ J. Lelieveld et al., 'The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale', *Nature*, 2015, 525, (7569), pp. 367–371.

⁸ <http://apps.who.int/gho/data/node.wrapper.ENVHEALTH-HAP?lang=en&menu=hide>.

¹ R. W. Allen et al., 'An Assessment of Air Pollution and its Attributable Mortality in Ulaanbaatar, Mongolia', *Air Quality, Atmosphere & Health*, 2013, 6, (1), pp. 137–150.

² Guttikunda SK, Lodoysamba S, Bulgansaikhan B, Dashdondog B. Particulate Pollution in Ulaanbaatar', *Mongolia. Air Qual Atmos Heal*. 2013;6: 589-601. doi:10.1007/s11869-013-0198-7

³ C.Ochir et al., 'Final Project Report: Air Pollution and Health in Ulaanbaatar', Ulaanbaatar, Mongolia, 2014.

estimated globally. In addition, air pollution is known to affect birth outcomes through low birth weight and prematurity, and can also result in lung damage that affects the health and well-being of children throughout their lives.⁹ Protection from air pollution is therefore critical for the welfare of children in Mongolia.

1.2. THE HEALTH IMPACTS OF AIR POLLUTION IN ULAANBAATAR

Although air pollution is a complex mixture of health-damaging pollutants, the primary indicator of health effects for combustion-related pollution is still PM_{2.5}, particles with an aerodynamic diameter of less than 2.5 µm that can penetrate deep into the lungs. There is more information on the health effects of this pollutant than any other, although it is recognized that for some diseases it may be an indicator of combustion pollution in general and that other pollutants may play a role in observed health effects. Only in the case of PM_{2.5}, however, are there exposure-response relationships available for the major disease outcomes on which burden of disease estimates are based.

Global burden of disease estimates demonstrate the significant impact of air pollution on health in Mongolia, where the three diseases that resulted in the most lost life years in 2013 were air pollution-related.¹⁰

In Ulaanbaatar, premature mortality is dominated by cardiovascular disease (heart disease and stroke), while lost disability-adjusted life years (DALYs) are primarily impacted by cardiovascular disease and pneumonia in children.¹¹

The global burden of disease assessment involved extensive review of the world scientific literature on the health effects of air pollution. For five diseases, it found compelling evidence to derive quantitative relationships between disease and pollution exposure, although there is evidence for other disease impacts.¹² For example, Enkhmaa et

al.¹³ found strong statistical correlations between ambient air pollutants and spontaneous abortion in Ulaanbaatar, and Dorj et al.¹⁴ found significant associations of air pollution in Ulaanbaatar with low birth weight in full-term births. Table 1 below shows the prevalence and relative ranking of the five air pollution-related diseases identified in the global disease burdens in Ulaanbaatar in 2015.¹⁵

Table 1. Air pollution-related disease burden in Ulaanbaatar in 2015¹⁶

Estimated disease burden for Ulaanbaatar, 5 diseases, 2015			Relative ranking
Disease	Deaths	DALYs	Years of life lost
Children under 5			
Pneumonia as an acute lower respiratory infections (ALRI) (aged 0–4)	435	37,290	2
Adults			
Ischemic heart disease	2,151	47,903	1
Cerebrovascular disease (stroke)	1,493	34,321	3
Chronic obstructive pulmonary disease	453	17,739	17
Cancer of the trachea, bronchus, lung	233	5,826	18

In Ulaanbaatar, pneumonia as an ALRI easily contributes most of the health burden from air pollution-related disease in children. Exposures to air pollution during childhood, however, may also contribute to the incidence of chronic air pollution-related disease later in life. For example, structural remodeling as a result of respiratory disease that interferes with the growth of air passages at crucial periods may have long-term effects on respiratory health, and there is little evidence of catch-up afterwards.¹⁷ In another example, long-term improvements in air quality were associated with statistically and clinically

Global Burden of Disease Study 2010', Lancet, 2012, 380, (9859), pp. 2224–2260.

¹³ Enkhmaa, D., et al., 'Seasonal Ambient Air Pollution Correlates Strongly with Spontaneous Abortion in Mongolia', BMC Pregnancy and Childbirth, 2014, 14, (1), p. 146.

¹⁴ Dorj, G., Dayan, A., Nanjid, K., Lkhagvaa, U. and Ochir, C. (2014) Is Air Pollution a Risk Factor for Low Birth Weight in Ulaanbaatar, Mongolia?. Open Access Library Journal, 1, 1-6. doi: 10.4236/oalib.1100885.

¹⁵ Ochir et al., op.cit.

¹⁶ Ibid.

¹⁷ S. Saglani et al., 'Early Detection of Airway Wall Remodeling and Eosinophilic Inflammation in Preschool Wheezers', American Journal of Respiratory and Critical Care Medicine, 2007, 176, (9), pp. 858–864.

⁹ W. J. Gauderman et al., 'Association between Air Pollution and Lung Function Growth in Southern California Children', American Journal of Respiratory and Critical Care Medicine, 2000, 162, (4), pp. 1383–1390.

¹⁰ Institute for health metrics and evaluation (IHME), Mongolia 2013, <www.healthdata.org>.

¹¹ Ochir et al., op.cit.

¹² Lim, S. et al., 'A Comparative Risk Assessment of Burden of Disease and Injury Attributable to 67 Risk Factors and Risk Factor Clusters in 21 Regions, 1990–2010: A Systematic Analysis for the



significant positive effects on lung function growth in children¹⁸ and many disease outcomes, such as chronic obstructive pulmonary disease, lung cancer and cardiovascular disease, are the result of lifetime exposures to air pollution.

Both short- and long-term exposures to particulate matter are associated with increased risk for cardiovascular events and hospital admissions for pneumonia,^{19,20} however exposure-response estimates for chronic health impacts of air pollution in global burden of disease estimates are based on long-term averages of air pollution exposure. Although peak exposures may play a role in health impacts, there is currently insufficient evidence to characterize them. The impact of air pollution on health is not as a result of exposure to it in any one place, but in all of the places in which people spend time, combined with individual susceptibility to expression of disease. For children, exposure to pollution during vulnerable periods of development also has a critical impact. For this reason, interventions need to focus on the environments that dominate children's exposures during these windows of vulnerability (exposure locations).

A focus on exposure rather than ambient air pollution concentrations more accurately reflects the contribution of different indoor locations where people spent their time, and thus the health benefits of interventions in different locations.

¹⁸ W. J. Gauderman, 'Association of Improved Air Quality with Lung Development in Children', *New England Journal of Medicine*, 2015, 372, (10), pp. 905–913.

¹⁹ J. Negrison and L. F. Nascimento, 'Atmospheric Pollutants and Hospital Admissions Due to Pneumonia in Children', *Revista paulista de pediatria: orgao oficial da Sociedade de Pediatria de Sao Paulo*, 2013, 31, (4), pp. 501–506.

²⁰ R. D. Brook et al., 'Air Pollution and Cardiovascular Disease: A Statement for Healthcare Professionals from the Expert Panel on Population and Prevention Science of the American Heart Association', *Circulation*, 2004, 109, (21), pp. 2655–2671.

Expression of health effects in response to air pollution exposures are dependent on other intrinsic and extrinsic risk factors that interact with air pollution in the expression of disease. Thus, tackling air pollution-related diseases resulting from exposures to children requires an integrated approach that targets reducing air pollution exposures, reducing disease prevalence through vaccination, and reducing modifiable risk factors that contribute to disease. Reducing exposures requires policies that target all environments where children spend their time, especially during critical windows of vulnerability, including the legal, regulatory and organizational frameworks that govern each location.

1.3. EXPOSURE LOCATIONS AND MOST VULNERABLE CHILD SUB-POPULATIONS

As mentioned above, exposure to air pollution among children results in a large direct burden of disease due to ALRI, which in turn may increase susceptibility to chronic air pollution-related disease. For example, both non-severe and severe pneumonia increased the risk of at least one long-term major chronic condition, most commonly a reduction in lung function.²¹ In addition, air pollution exposures and repeated incidence of pneumonia in children are both linked to increased incidence of chronic air pollution-related disease later in life.²²

The time periods of vulnerability for these critical outcomes are different, however, with the vast majority of ALRIs resulting from risk factors and

²¹ K. Edmond et al., 'Long Term Sequelae from Childhood Pneumonia; Systematic Review and Meta-Analysis', *PLoS One*, 2012, 7, (2), p. e31239.

²² S. S. Salvi and P. J. Barnes, 'Chronic Obstructive Pulmonary Disease in Nonsmokers', *Lancet*, 374, (9691), pp. 733–743.



exposures during the period from pre-pregnancy to 2 years old, with the most critical windows for air pollution and infection in the first two to three months of life. In contrast, air pollution exposures that lead to later chronic respiratory disease may affect lung growth throughout development, with critical periods of vulnerability reflecting time periods for organ development and maturity.

The structure and function of the lungs are permanently altered in their design by factors operating during sensitive periods of fetal or early postnatal life.²³ Much of lung development is prenatal; mothers' prenatal smoking and passive smoking have been extensively studied and are associated with irreversible alterations in lung growth.^{24,25} After birth, infants and toddlers ventilate with a flaccid ribcage, resulting in less effective ventilation, a less effective diaphragm, and lowered functional residual capacity. Alveolar development is completed by the age of 3, after which growth occurs mainly by enlargement.

There is a gradual increase in thoracic stiffness and lung compliance which continues during childhood, resulting in an under-distension of the lungs below the ages of 7–8 and an over-distension above these ages.²⁶ The factors that adversely affect growth of the respiratory system have been covered elsewhere in much more detail (e.g. Greenough²⁷); the main point to note is that the development of children's lungs occurs throughout childhood and measures should be taken at all stages to reduce their exposure

to air pollution. Clearly a priority is to reduce exposure at home during early development to decrease pneumonia and the impact on lung development; however, measures should also be taken to reduce exposures in school-age children to decrease the impacts of air pollution-related diseases later in life.

Children's vulnerability to air pollution-related disease varies with age, as exposure environments change significantly during childhood. Time activity studies show that adults and children spend over 90 per cent of their time indoors, confirming that indoor environments dominate exposures to air pollution and the resultant health impacts. The home indoor environment is particularly important for young infants susceptible to acute pneumonia infections. They spend nearly all their time indoors at home during Mongolian winters, with mothers of children under 2 receiving a child home care allowance from the social pension fund. In Ulaanbaatar, there are some privately run nursery schools that provide day care to children under 3, after which they may attend kindergarten. Primary education caters to children from the age of 6, lower secondary from 12 to 14, and upper secondary from 15 to 18.²⁸

Exposures of school-age children depend on the time and mode of transport to school, the school's location and heating system, and the time of day when children attend school. Since schools are in different locations to children's homes, with different neighborhood sources, building penetration rates, and heating sources, school indoor environments are likely to have

²³ P. Merkus and A. Hislop, 'Lung Development from Infancy to Adulthood', *European Respiratory Monograph*, 2006, 37, p. 8.

²⁴ *Ibid.*

²⁵ G. S. Maritz, C. J. Morley, and R. Harding, 'Early Developmental Origins of Impaired Lung Structure and Function', *Early Human Development*, 2005, 81, (9), pp. 763–771.

²⁶ Merkus and Hislop, *op.cit.*

²⁷ A. Greenough, 'Factors Adversely Affecting Lung Growth', *Paediatric Respiratory Reviews*, 2000, 1, (4), pp. 314–320.

²⁸ Secondary education regional information base: country profile – Mongolia. Bangkok: UNESCO Bangkok, 2009 <http://www.uis.unesco.org/Library/Documents/Mongolia.pdf>

different air pollution concentrations. The time of day is important since ambient air pollution concentrations vary widely over a 24-hour period due to diurnal patterns of fuel consumption and emissions, combined with a raising of the mixing height in the atmosphere during the day. For primary school children from first to third grade, the school day is typically from 11:30 a.m. to 4:30 p.m. From fourth to eighth grade, school starts at 8:00 a.m. and finishes at 13:10 p.m., and high schools typically run from 13:10 p.m. until 6:30 p.m. If the school is just a primary school, then schedules may vary.

1.4. PNEUMONIA IN CHILDREN

Ninety-five per cent of all deaths from ALRIs occur in low- and middle-income countries,²⁹ with 81 per cent of deaths from pneumonia occurring in the first two years of life.³⁰ Major risk factors for mortality from ALRI in children under 5 in low- and middle-income countries are diagnosis of very severe pneumonia (WHO definition), being less than 2 months of age, and having underlying chronic disease, HIV or severe malnutrition. In addition, socioeconomic and environmental factors also contribute through air pollution, young maternal age, low maternal education, and environmental tobacco smoke exposure.³¹ Respiratory infection is the second largest cause of infant and under-five mortality in Mongolia, accounting for 15 per cent of infant deaths in children under 5.³²

Causes of life-threatening invasive bacterial infections in the neonatal period are uncertain, as infections could be environmentally rather than perinatally acquired; however, even hospital-born babies in developing countries have a 3 to 20 times greater risk of neonatal infections because of poor infection-control practices.³³ As children grow older, the causes of clinical pneumonia are mainly respiratory syncytial virus (RSV),

influenza virus, *Streptococcus pneumoniae*, and *Haemophilus influenzae*.

RSV infection is the major global cause of ALRIs. In South Africa, viral pathogens were found in 78 per cent of children under 5 years with ALRIs,³⁴ and 80 per cent of children at 2 years of age have been infected with RSV, of whom one-third will have developed an ALRI, usually bronchiolitis (inflammation of the small airways in the lung).³⁵ Major risk factors for severe RSV leading to hospitalization include lower gestational age, less than 3 months of age at the onset of the RSV season, and living with school-age siblings. Tobacco smoke exposure evidence was mixed, and lack of breastfeeding and poor nutrition did not appear to increase the risk of severe RSV infection.³⁶

Important vaccine-preventable causes of severe pneumonia are *S pneumoniae* (which causes at least 18 per cent of severe episodes and 33 per cent of deaths worldwide), the influenza virus (7 per cent of severe episodes and 11 per cent of deaths), and *H influenzae* type b (4 per cent of severe episodes and 16 per cent of deaths).³⁷ The effects of air pollution, however, are more pronounced for bacterial causes of pneumonia compared to RSV,³⁸ although there is evidence for the role of viral pathogens in bacterial pneumonia.³⁹

²⁹ M. Sonogo et al., 'Risk Factors for Mortality from Acute Lower Respiratory Infections (ALRI) in Children under Five Years of Age in Low and Middle-Income Countries: A Systematic Review and Meta-Analysis of Observational Studies', *PloS One*, 2015, 10, (1).

³⁰ C. L. F. Walker et al., 'Global Burden of Childhood Pneumonia and Diarrhoea', *Lancet*, 2013, 381, (9875), pp. 1405–1416.

³¹ Sonogo et al., *op.cit.*

³² Country statistics and global health estimates by WHO and UN partners (January 2015) <http://www.who.int/gho/countries/mng.pdf?ua=1>.

³³ Walker et al., *op.cit.*

³⁴ C. Cohen et al., 'Severe Influenza-associated Respiratory Infection in High HIV Prevalence Setting, South Africa, 2009–2011', *Emerging Infectious Diseases*, 2013, 19, (11), pp. 1766–1774.

³⁵ J. M. Pettifor, 'Acute Lower Respiratory Infections in Children', *South African Journal of Child Health*, 2015, 9, (2), p.

³⁶ E. A. Simoes, 'Environmental and Demographic Risk Factors for Respiratory Syncytial Virus Lower Respiratory Tract Disease', *Journal of Pediatrics*, 2003, 143, (5), pp. 118–126.

³⁷ Walker et al., *op.cit.*

³⁸ K. R. Smith et al., 'Effect of Reduction in Household Air Pollution on Childhood Pneumonia in Guatemala (RESPIRE): A Randomised Controlled Trial', *Lancet*, 2011, 378, (9804), pp. 1717–1726.

³⁹ S. A. Madhi, K. P. Klugman, and T. V. T. Group, 'A Role for *Streptococcus pneumoniae* in Virus-associated Pneumonia', *Nature Medicine*, 2004, 10, (8), pp. 811–813.

PART 2: TOWARDS A SET OF COMPREHENSIVE AND URGENT POLICY RESPONSES



2.1. BARRIERS

Based on a rapid assessment and subsequent meetings with key stakeholders, an integrated framework of policies and actions has been developed as part of this report and with the aim of suggesting actions to reduce the burden of disease from children's exposure to air pollution in the ger areas of Ulaanbaatar. This framework is built on a causal analysis and is summarized in the Table 2 below.

Table 2. Reducing air pollution-related disease in children

Barriers	
<ul style="list-style-type: none"> - Lack of general knowledge of the burden of disease and health impacts, in particular on children - Lack of awareness of intervention approaches - Lack of advocacy for integrated approaches to child health <ul style="list-style-type: none"> • Limited coordination within Government and between private sector approaches • Lack of policy coherence, implementation and enforcement of regulations and standards 	
Integrated goals to reduce air pollution-related disease in children	
<ul style="list-style-type: none"> - Reduce exposures by switching to clean fuels in homes and schools - Reduce incidence of pneumonia by vaccination and community care treatment - Reduce risk factors for disease, including exposure to tobacco smoke, undernutrition, lack of exclusive breastfeeding, zinc deficiency 	
Policy approaches	Action on the ground
1. Increase awareness on the need to switch to clean fuels in homes and schools and accelerate actions targeted to child health and pneumonia prevention	1. Prenatal care and first year of life <ul style="list-style-type: none"> - Tackle exposure to tobacco smoke - Accelerate introduction of pneumococcal vaccine - Strengthen actions on child nutrition and exclusive breastfeeding - Target community care centers with provision of antibiotics, nutrition, heating fuel - Install air filters as part of antenatal care programs during pregnancy and year 1
2. Convene a multi-stakeholder platform for information-sharing and coordination	
3. Develop capacity <ul style="list-style-type: none"> - Knowledge and skills - Human resources - Technical ability - Regulation and compliance 	2. Home <ul style="list-style-type: none"> - Promote use of clean fuels - Address tobacco smoke exposure - Provide insulation and vestibules for better energy efficiency
4. Identify gaps in knowledge base and messages to be targeted by research groups	
5. Increase awareness of air pollution policies used in countries with similar climatic conditions, institutions, budgets required to address specific interventions, monitoring and evaluation <ul style="list-style-type: none"> - National - Municipal - City zoning 	3. Schools <ul style="list-style-type: none"> - Awareness and health/environmental education for children - Replace heat-only boilers in schools with gas-fired boilers - Filtration in air ducts/HVAC systems where installed - Nutrition programs - Exercise advisories for high pollutant episodes

The barriers identified in the rapid assessment include a lack of knowledge of the relationship between air pollution and disease burdens, lack of connection between scientific evidence and policy development, and limited coordination of this information between ministries and other stakeholders. In particular, there was a lack of awareness of and advocacy for the importance of integrated approaches for addressing air pollution-related diseases in children, and recognition of the impacts of this exposure throughout later life.

Although there is general consensus that the air pollution situation will only be resolved when burning raw coal for heating is replaced with gas fuels, combined with the expansion of district heating in central areas, there is little awareness of other possible interventions that can be applied to different segments of the population beyond cleaner-burning stoves. While the private sector has worked with the Government to address air pollution, particularly in the areas of cleaner-burning stoves and insulation, greater

coordination between ministries and within the private sector would make initiatives more effective and coherent.

Finally, although there has been considerable regulatory activity on air pollution within the last few years, a greater coherence of policies across sectors could be achieved. For example, subsidies for buying raw coal and shifts from one coal type to another should be better coordinated with requirements for reduced air pollution emissions and the suitability of fuels for use in household stoves. Further, these subsidies should be evaluated in comparison to investing in cleaner-burning alternatives, considering the potential health impacts from air pollution in the population.

2.2. SUGGESTED POLICY INTERVENTIONS AND APPROACHES

Over the last few years the Government of Mongolia has enacted a large number of measures aimed at reducing air pollution in Ulaanbaatar. These include significant investment in energy efficiency programs in cooperation with multilateral institutions such as the World Bank, the Asia Development Bank, the European Union and the United Nations Development Program, and through bilateral agreements with countries such as the United States, Japan, the Republic of Korea, Germany and Norway. Household-level interventions include large programs for cleaner-burning stoves, and small initiatives for insulation, vestibules and low-pressure boilers. In addition, the Mongolian Government has passed major laws to regulate air pollution (Law on Air 2012), ambient standards and technical requirements, and emissions standards for air pollution sources including vehicles (see Appendix 3).

Though this represents a major step forward in tackling air pollution in Ulaanbaatar and Government's commitment should be acknowledged, unfortunately technical capacity, human resources and enforcement abilities have progressed more slowly. In addition, although various laws have been drafted, and a high-level National Committee on Air Pollution Reduction convened, there is still a need to formalize a strategic road map of how to lessen health impacts by reducing air pollution to WHO air quality

guidelines, with a national budget to achieve these goals.

There is a general consensus among experts and practitioners in the field of air pollution in Mongolia, that a comprehensive response plan to drive down the incidence of air pollution-related disease in Ulaanbaatar's children should pursue the three main strategic goals below:

1. Switching to clean fuels in homes and schools to reduce exposures to air pollution.
2. Increasing the coverage of vaccination and treatment in community care centres to reduce the incidence of pneumonia.
3. Tackling the risk factors for air pollution-related disease, including tobacco smoke exposure, undernutrition, and lack of exclusive breastfeeding.

In this regard, increasing citizens' awareness of the need to switch to clean fuels in homes and schools would be also most important to consider. While this is generally acknowledged by the Government and international groups, there is still a lack of systematic evaluation of the costs of different approaches, and the timeframe over which the transition would occur. In addition, it is not clear how much the residents of ger districts and other Ulaanbaatar citizens recognize this need as a key and urgent priority.

Although a recent analysis indicated that the cost of delaying this transition would be substantial in terms of avoiding ill health,⁴⁰ this is not always recognized and taken into account at policy level. Air pollution was identified in the Millennium Challenge Corporation constraints to economic growth analysis for the second Millennium Challenge compact, but air pollution measures were not further pursued in the second compact. The first compact however showed very clearly that further measures were required to reduce air pollution concentrations towards WHO air quality guidelines. This demonstrates the need for improved acknowledgement of the economic burdens of air pollution in Ulaanbaatar, and the benefits of investing in intervention strategies quickly rather than more gradually, a choice

⁴⁰ Ochir et al., op.cit.



with substantial differences in cost and strategic approaches.

Another priority is to address limited coordinated strategic plans across stakeholders. Convening a biannual multi-stakeholder meeting to share information and coordinate action would be a first step in addressing this issue if sufficiently attended by both government ministries and other stakeholders. Ideally, this meeting would be convened by an independent party to facilitate open sharing of information. Such a platform would facilitate efficient use of resources and could also be used to target the capacity building that is required institutionally in terms of knowledge, trained human resources, technical ability, financial resources and equipment.

It would also provide a vehicle for researchers to communicate directly with stakeholders, to identify and address some of the significant gaps in information. While some of these are gaps in locally conducted research (see Appendix 2 for air pollution studies conducted in Ulaanbaatar), others are in basic statistics and demographic information. It should be noted, however, that as there is a sufficient body of international literature available on air pollution-related disease, it is not necessary to repeat all studies on health outcomes in Ulaanbaatar to know that air pollution is causally

related to these diseases. Although capacity building is needed in government agencies, local communities, schools and research universities, it is particularly needed in compliance monitoring and enforcement of standards, where basic monitoring equipment to measure and enforce compliance is lacking in some cases.

2.3. SPECIFIC INTERVENTIONS ON THE GROUND: TARGETING CHILDREN'S ENVIRONMENT

These interventions should focus on the three principal environments in which children are exposed to air pollution: prenatal care and during the first year of life, indoors at home, and indoors at school, with clear institutional accountability levels for coordinating activities. Although transport contributes to exposures, transport-related policies are probably better addressed through the framework of emissions and fuel-testing used by other nations to tackle similar issues.

2.3.1. REDUCING EXPOSURES AT HOME

Indoor air pollution in *gers* and houses dominates exposures⁴¹ and arises from indoor sources, largely fugitive emissions from heating stoves, cooking and smoking, but also from the

⁴¹ Ibid.

penetration of outdoor ambient air pollution. Intervention measures can be directed at each of these contributing sources.

• HEATING STOVES

The US Millennium Challenge Corporation, through its compact with the Government of Mongolia, introduced the Energy and Environment Project in 2011 to reduce air pollution. From 2011 to 2014 the Millennium Challenge Energy Efficiency Innovation Facility provided consumer subsidies to buy 103,255 lower-emission stoves for heating and cooking, over 20,000 sets of two additional *ger* insulation layers made of felted wool, and more than 5,000 vestibules (small structures at the entrance of a *ger* designed to separate inside and outside air to prevent heat loss). It also provided technical assistance in assessing the viability of such technologies, and funds to replace 15 highly inefficient outdated heat-only boilers (which provided central heating in large buildings and institutions) at 10 sites across Ulaanbaatar.⁴² Use of lower-emission stoves saw household emissions across Ulaanbaatar drop by an estimated 30 per cent, with the largest reductions in highly polluted areas that were more heavily targeted by the program.⁴³

The stove program reduced population-weighted annual average exposures to PM_{2.5} in Ulaanbaatar by an estimated 11.5 per cent. For 2012, this exposure reduction would have implied a 9 per cent reduction in the incidence of air pollution-related lung cancers, 8.3 per cent reduction in the incidence of air pollution-related chronic obstructive pulmonary disease, 8.1 per cent reduction in the incidence of air pollution-related ALRI in children between the ages of 0 and 4, a 4.9 per cent reduction in the incidence of air pollution-related ischemic heart disease, and a 2 per cent reduction in the incidence of air pollution-related strokes.⁴⁴ These estimates focus only on one year (2012–2013), and to estimate the overall impact of this intervention, the program should be assessed over the functional lifetime of the Millennium Challenge Account (MCA) stoves.

Although estimating the total number of stoves

present in Ulaanbaatar's *ger* districts has proved difficult, extending the distribution of these stoves to all *gers* and households in Ulaanbaatar that use raw coal in space heating stoves would further reduce air pollution impacts. Clearly, however, this would be facilitated by better inventories and census data on stoves and dwellings.

The World Bank, Mongolia continued to subsidize and disseminate these stove models, and further support is warranted, however this is still only the first step in reducing disease burdens from air pollution. Indoor air pollution and population-weighted annual average exposures with these stoves still remains high, and there are strong economic incentives to facilitate a transition to gas fuels for use in domestic heating stoves sooner rather than later (whilst ensuring they still vent emissions outside), combined with shifting a greater percentage of the population to district heating (which eliminates combustion from the home, thus reducing exposures).⁴⁵ While cleaner-burning processed coal fuels and stoves with lower fugitive emissions can be promoted, they are unlikely to drive pollution levels low enough to achieve the desired health benefits in the long term, and resources would be better used to transition to household use of gas fuels or district heating. To facilitate this transition, developing coal to gas facilities are recommended in the short term, combined with increasing exploitation and infrastructure to develop shale oil gas and other natural reserves.

• THE IMPORTANCE OF CLEAN FUELS

Liquid or gas fuels for heating and cooking are generally much cleaner than solid fuels, in addition to being more energy-efficient and generally more convenient. Prior to the development of natural gas supplies and distribution systems, virtually all gas used for heating in the United Kingdom and the United States was derived from coal.

In the United Kingdom, the 1956 Clean Air Act introduced 'smoke control areas' where only smokeless fuels could be burned, which dramatically increased the spread of gas fuels for heating in residential areas. Although not a ban on solid fuels, the Act required authorized fuels

⁴² Ibid.

⁴³ Ibid.

⁴⁴ Ibid.

⁴⁵ Ibid.

to pass tests confirming that they would burn in an open fireplace without producing smoke, and appliances used for burning unauthorized solid fuels had to pass tests confirming that unauthorized fuel would burn without emitting smoke. By regulating and prohibiting widely accepted activities within private households, the Clean Air Act changed the debate about permissible areas for government intervention based on inherent hazards to public health.

Originally, the first coal gas used in London was produced by the carbonization and partial pyrolysis of coal. Subsequently, with the development of natural gas reserves in the North Sea, coal gas was replaced with natural gas for domestic use. Both had an odorant called mercaptan added to warn of gas leaks, but natural gas was inherently safer as it did not contain carbon monoxide. In the vast majority of homes these stoves vent emissions outside. More recently in Finland and other Scandinavian countries with winter temperatures close to Mongolia, air pollution exposures in urban areas have been reduced to WHO air quality guidelines, largely through the elimination of combustion appliances for heating and cooking in the home through a transition to district heating from power plants located outside urban areas.

In the United States, the European Union and Canada, measures to reduce air pollution from heating stoves using solid fuels include financial incentives for fuel-switching and technology change, and use of more efficient heating technologies (such as certified fireplaces or pellet stoves). In addition, the United States and Canada set technology-based emission limits, and eco-design regulations and labels are used in the European Union.⁴⁶

'Clean' fuel options at the residential level in Ulaanbaatar should include:

1) District heating

Increasing the proportion of the population served by district heating would have a beneficial effect because, although currently a cogeneration

product from coal-fired power plants, district heating is 'clean' at the household level as it has no household-level emissions. Exposure would therefore be the result of the fraction of ambient emissions from cogenerating coal-fired power plants that penetrates homes. In addition, cogenerating power plants in Ulaanbaatar use emission-control technologies and are more energy-efficient than the household-level use of raw coal.

2) Liquid petroleum gas

Liquid petroleum gas (LPG) is currently imported into Ulaanbaatar for use in restaurants and LPG cookers, heaters, and vehicles. LPG usage is growing rapidly, with an 18-fold increase since 2000.⁴⁷ Although crude oil is extracted from conventional deposits in Mongolia for export to China, there are plans to build a refinery in Mongolia.⁴⁸ Until built, however, Mongolia is likely to continue to import refined petroleum products, mostly petrol and diesel, from Russia. Should a local refinery be built, LPG for the domestic market could significantly mitigate air pollution in Ulaanbaatar, with significant health and economic benefits.

3) Syngas, LNG and CNG

There appears to be interest in Mongolia in a coal to synthetic natural gas (SNG) unit, with likely Korean investment given as US\$0.9 billion for an SNG plant with a capacity close to 0.5 Mt.⁴⁹ In addition, there is considerable interest in underground coal gasification as a promising technology to reduce the cost of producing syngas from coal,⁵⁰ particularly as a means to produce synthetic petroleum products in order to reduce the import dependency on Russia.⁵¹ Underground coal gasification is the in situ gasification of coal in the seam, achieved by injecting oxidants, gasifying the coal and removing the product gas through boreholes drilled from the surface.⁵² Methane or natural gas extracted from coal gasification can

⁴⁷ <http://unigas.mn/?id=18&l=en>.

⁴⁸ UNCTAD, 'Investment Policy Review: Mongolia', 2013, UNCTAD/DIAE/PCB/2013/3.

⁴⁹ A. J. Minchener, 'Energy Issues for Mongolia', USEA Clean Coal Center, 2013, ISBN 978-92-9029-535-8.

⁵⁰ P. Pei et al., 'Cost Comparison of Syngas Production from Natural Gas Conversion and Underground Coal Gasification. Mitigation and Adaptation Strategies for Global Change', 2014, pp. 1–15.

⁵¹ A.J Minchener, op. cit.

⁵² Ibid.

⁴⁶ WHO Europe, Residential Heating with Wood and Coal: Health Impacts and Policy Options in Europe and North America, 2015, ISBN 978-92-890-5076-0.

be converted into SNG, liquid natural gas (LNG), or compressed natural gas (CNG). LPG can also be produced by synthesizing SNG with partial reverse hydrogenation at high pressure and low temperature.⁵³ Should capacity be developed, use in the domestic market could significantly mitigate air pollution in Ulaanbaatar, with consequent health and economic benefits.

4) Natural gas from shale reserves

Mongolia's large shale gas reserves are mostly based in the south and eastern parts of the country, but there may also be reserves in other areas, including around Ulaanbaatar. Exploitation of these reserves is of strategic interest but there are difficult trade-offs, such as locating adequate water supplies, and developing adequate safety and environmental regulations for sustainable development. The development of shale reserves has the potential to significantly mitigate air pollution in Ulaanbaatar, but the market is not sufficiently large to support development costs without securing export markets and pipelines.

5) Dimethyl ether

Dimethyl ether (DME) can be manufactured from raw coal and is relatively inert, non-corrosive, non-carcinogenic, and has a low toxicity. It has similar properties to those of propane and butane, which are the principal constituents of LPG, and can be handled and stored using the same technology, provided care is taken with rubber sealants. It burns with a visible blue flame similar to that of natural gas, and doesn't produce aldehydes.⁵⁴ The largest capacity for DME plants for use as a domestic fuel is in Asia, with multiple plants in China, and plans to build plants in Japan, Papua New Guinea, and Iran.⁵⁵

DME synthesis from syngas in plants that process coal in a single throughput generate considerable electricity by-product, which contributes significantly to the DME economics, and would also help reduce Ulaanbaatar's air pollution. Absolute

coal consumption is projected to fall with DME synthesis, due to inefficient combustion of raw coal and the benefits of the electricity by-product, with approximate production costs in 2002 of US\$ 250–350/tonne LPG equivalent, which were within the range of LPG costs with even moderate transport requirements in China.⁵⁶

• ENERGY EFFICIENCY AND INDOOR TEMPERATURES

Improved energy efficiency through insulation and vestibules in homes would reduce the amount of raw coal burned and thus particulate emissions into the ambient air, although there may be a rebound effect where people elect to live in somewhat warmer homes, either consciously or unconsciously.⁵⁷ In addition, increased insulation and vestibules would decrease the penetration efficiency of ambient pollution indoors, particularly in very cold winters, thus reducing exposures.

Improvements in energy efficiency in office, commercial, and institutional buildings in Ulaanbaatar would also reduce the amount of coal burnt for fuel. This can be achieved through rigorous application of building construction and insulation standards, but also through tighter regulation of indoor temperature norms. Excessive indoor temperatures in office and other buildings in Ulaanbaatar during the winter requires a greater energy input than necessary for comfort and results in greater coal combustion and thus air pollution emission to the atmosphere. Indeed, windows are often opened to reduce indoor temperature for comfort, which is not recommended from an air pollution exposure perspective.

Acceptable operating temperature ranges for comfort during the winter with relative humidity of around 60 per cent are 20–24°C, under both Canadian standards CAN/CSA Z412-00 (R2011) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 55–2010, Thermal Environmental Conditions for Human Occupancy.

These temperature ranges have been found to meet the needs of at least 80 per cent of

⁵³ E. D. Larson and H. Yang, 'Dimethyl Ether (DME) from Coal as a Household Cooking Fuel in China', *Energy for Sustainable Development*, 2004, 8, (3), pp. 115–126.

⁵⁴ Ibid.

⁵⁵ The Catalyst Group, 2007, *Global Dimethyl Ether Emerging Markets* available at http://www.aboutdme.org/EFIClient/files/ccLibraryFiles/Filename/000000000424/2007_DME_Seminar_9_Payne_CatalystGroup.pdf.

⁵⁶ E. D. Larson and H. Yang, op. cit.

⁵⁷ Ochir et al., op. cit.

individuals. Since average relative humidity in Ulaanbaatar during winter months is approximately 66 per cent, similar temperature ranges would also be appropriate in Ulaanbaatar, however, indoor building temperatures frequently exceed these values. Efficiency measures of this nature are low cost but may achieve significant benefits in air pollution reduction.

• HOUSING AND BUILDING STANDARDS FOR INSULATION

Houses in ger districts represent an aspirational goal for newly arrived residents of Ulaanbaatar. While ger insulation lasts approximately five years, houses constitute a much longer-term investment of 20–40 years. Unfortunately, current building practices in Ulaanbaatar are not standardized, particularly where insulation is concerned, but also in many other regards. Building codes are not freely available and followed. Since this represents a 20- to 40-year legacy, heating and insulation choices made now will affect Ulaanbaatar for years to come. Therefore, it is a priority to develop and apply building codes to reduce energy consumption and thus air pollution emissions. Where possible, houses should be connected to district heating or use vented gas heating appliances and vestibules should be promoted for all houses in Ulaanbaatar to minimize heat loss.

• INSULATION AND VESTIBULES

The Millennium Challenge Energy Efficiency Innovation Facility provided consumer subsidies for the purchase of over 20,000 sets of two additional ger insulation layers made of felted wool, and more than 5,000 vestibules. However, this represents a very low coverage across ger districts in Ulaanbaatar and most vestibules and insulation were not from the MCA program.

These interventions serve two purposes that may help reduce air pollution exposures. The first is to reduce heat loss and thus decrease the amount of fuel consumed. MCA stove owners in gers with three or more layers of felt insulation used 2.23 kg of coal less than traditional stove owners with the same level of insulation. On the other hand, those with two or fewer layers used approximately the same quantity of coal as traditional stove owners. These results suggest that bundling interventions

of stove purchase with higher insulation may be effective in encouraging compliance with cold start instructions and help to achieve intended fuel reduction benefits.⁵⁸ However there is some evidence of rebound effects where residents in Ulaanbaatar kept their houses on average almost 2 degrees warmer over a 24-hour period with MCA stoves relative to traditional stoves.

The second effect of ger insulation and vestibules may be to reduce ambient air pollution penetration indoors, although this has not been directly evaluated. Anecdotally, however, indoor concentration measures in houses and gers were substantially lower than ambient concentrations of particulate matter, especially at night during the winter when outdoor air temperatures approach -40°C.

• FILTRATION PRODUCTS

Until emission reductions are achieved across sectors, a number of intermediate measures can be promoted to reduce residential indoor concentrations of particulate matter, including the use of portable stand-alone mechanical filtration products that actively pass air across HEPA filters.

Passive ionization-based units are not recommended as they may lead to harmful levels of ozone indoors, and do not have sufficient airflow to reduce air pollution levels effectively. Use of filtration products would be particularly relevant in the prenatal period and up to 2 years of age. For example, characteristic pathologic features of asthma develop between the ages of 1 and 3, a time when intervention may modify the pathogenesis of disease.⁵⁹ Filtration products, however, would also benefit older children by reducing disease burdens later in life. More affluent Ulaanbaatar residents may consider induct central air cleaners for homes, but this will not address the needs of the majority of the population in ger districts.

2.3.2. REDUCING EXPOSURES AT SCHOOL

Interventions can also be targeted at the school and classroom level, where school-age children spend a significant amount of time. Modern school buildings equipped with central air handling

⁵⁸ Ibid.

⁵⁹ Saglani et al., op.cit.

HVAC systems can be equipped with HEPA filtration to reduce particulate indoor air pollution in the classroom. In Finland, evaluation of similar approaches in work environments showed that significant reductions in exposure were possible.⁶⁰

Older school buildings without HVAC systems should consider portable stand-alone mechanical

HEPA filtration units that actively pass air across a filter. Passive ionization-based units are not recommended as they may lead to harmful levels of ozone indoors, and do not have sufficient airflow to reduce air pollution levels effectively in classrooms. More guidance on air cleaners, including calculators that estimate flow rates required for a particular room size to determine which air cleaners are suitable, may be found on the California Air Resources Board website (<https://www.arb.ca.gov/homepage.htm>).

There seems to be limited information on indoor air concentrations for houses and gers in Ulaanbaatar and there is no clear indication on indoor air concentrations levels in classrooms. However, in houses and gers, indoor air concentrations were substantially lower than outdoor ambient concentrations.⁶¹ If the same holds true for classrooms, which is reasonable since indoor combustion sources are not present, playground activities outside the school building could be restricted on days with very high air pollution, as it is in California on high ozone days, where children don't play outside when there is an air pollution advisory.



2.3.3 REDUCING EXPOSURE TO OTHER SOURCES OF AIR POLLUTION

In addition to pollution at home and in school, a number of improvements in the regulatory framework and enforcement are recommended to reduce sources of ambient air pollution. While some form part of the master plan for Ulaanbaatar, they are included here for completeness. These include:

1. Retrofitting all currently existing power plants with emissions controls to reduce downwind impacts.
2. Accelerating the replacement of heat-only boilers in Ulaanbaatar, and in particular, those that supply heat to schools, and those close to residential *ger* areas.
3. Transitioning central Ulaanbaatar residents to apartment buildings connected to district heating.
4. Compiling inventories of industrial sources of air pollution, adopting emissions standards for industrial sources, and instituting a regulatory framework that will allow enforcement of emissions standards similar to those adopted by other industrialized nations. This is particularly important as little is known about industrial sources of air pollution in Ulaanbaatar.

⁶⁰ O. O. Hänninen et al., 'Reduction Potential of Urban PM_{2.5} Mortality Risk Using Modern Ventilation Systems in Buildings', *Indoor Air*, 2005, 15, (4), pp. 246–256.

⁶¹ Ochir et.al., op.cit.

5. Capacity building for emissions monitoring and development of regulatory frameworks for enforcement.

As a first step, improving the inventories of industrial emissions will help in modelling contributions from this sector; and building capacity for emissions monitoring in Ulaanbaatar would help to refine these estimates

2.3.4. ADDRESSING CHILD RELATED EFFECTS: REDUCING EXPOSURES DURING PRENATAL CARE AND THE FIRST YEAR OF LIFE

Interventions should focus on reducing tobacco smoke exposure, increasing coverage of pneumococcal vaccines, increasing the capacity of community care centers to treat pneumonia infections through antibiotics, immunoprophylaxis with palivizumab (monoclonal antibody) against RSV in high-risk children, increasing exclusive breastfeeding in the first six months, and addressing nutritional deficiencies. Many of these interventions form part of the Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhoea. In addition, the heating fuel/sources used in community care centers during winter months need to be evaluated to reduce exposures attributed to them.

• USE OF PNEUMOCOCCAL VACCINES TO PREVENT PNEUMONIA

Existing cost-effective interventions could prevent 67 per cent of pneumonia deaths in children under 5, largely through new vaccines combined with the knowledge of how to best deliver these interventions through community case management.⁶² *S pneumoniae*, *H influenzae*, and influenza virus are three of the four main causes of pneumonia mortality. Reduction of risk factors, immunization, and case management comprise the main approaches to disease control.⁶³ High coverage of vaccines against these pathogens has the potential to reduce mortality and severe morbidity substantially. Immunization and good antenatal practices are associated with decreased

odds of death from ALRI.⁶⁴

Vaccination with a 9-valent pneumococcal conjugate vaccine reduced the incidence of radiologically confirmed pneumonia, and also reduced the incidence of vaccine serotype and antibiotic-resistant invasive pneumococcal disease among children with and without HIV infection.⁶⁵ There is also improved understanding and recognition of risk factors and infections and therefore opportunities for intervention during the pre-pregnancy period, pregnancy, and the first two years of life. These include care during pregnancy to reduce intrauterine growth retardation, improving infant and young child nutrition, and reducing air pollution exposures and environmental health risks.⁶⁶

The importance of bacterial pathogens as a cause of ALRI is falling quite rapidly because of widespread vaccination of *Haemophilus influenza* type b and pneumococcal vaccines in many low- and middle-income countries as part of the Expanded Program of Immunization. In HIV-negative children, the 9-valent pneumococcal vaccine has reduced invasive pneumococcal disease by 83 per cent and ALRIs by 20 per cent.⁶⁷ National coverage of the routine Expanded Program on Immunization in Mongolia is more than 96 per cent, however, some of the most cost-effective vaccines against pneumonia and diarrheal diseases, the main killers of Mongolian children, are still not included.⁶⁸ In Ulaanbaatar, additional efforts should also be made to vaccinate the mobile and unregistered population of migrants.⁶⁹ High coverage of vaccines in Ulaanbaatar would shift the pneumonia case burden to neonates and early infancy, with corresponding increases in the cost of case management. Thus, although dramatic reductions in overall incidence would result, the remaining cases would incur greater health service costs per case.⁷⁰

⁶⁴ Sonogo et al., op.cit.

⁶⁵ K. P. Klugman et al., 'A Trial of a 9-Valent Pneumococcal Conjugate Vaccine in Children with and those without HIV Infection', *New England Journal of Medicine*, 2003, 349, (14), pp. 1341–1348.

⁶⁶ Z. A. Bhutta et al., 'Interventions to Address Deaths from Childhood Pneumonia and Diarrhea Equitably: What Works and at What Cost?' *Lancet*, 2013, 381, (9875), pp. 1417–1429.

⁶⁷ Klugman et al., op.cit.

⁶⁸ WHO Geneva, Country Cooperation Strategy for Mongolia 2010–2015.

⁶⁹ Ibid.

⁷⁰ Walker et al., op.cit.

⁶² M. Chopra, et al., 'Ending of Preventable Deaths from Pneumonia and Diarrhoea: An Achievable Goal', *Lancet*, 2013, 381, (9876), pp. 1499–1506.

⁶³ Walker et al., op.cit.

Although there are no vaccines available at the time of this research, a vaccine against RSV is in development and prophylaxis of immune globulin with a high titer of antibodies against RSV⁷¹ or monoclonal antibody palivizumab⁷² are effective for preventing RSV in high-risk infants, including infants and children under 2 with chronic lung disease, and premature infants. A recent meta-analysis of studies have shown estimates of efficacy of up to a 70 per cent reduction in RSV hospitalization in infants and children with chronic lung disease, and a reduction of between 80 per cent and 82 per cent in preterm infants, compared with control infants.⁷³ While there are other causes of pneumonia that are not preventable by vaccination,⁷⁴ pneumococcal vaccines combined with prophylaxis against RSV in high-risk cases can substantially decrease health burdens due to ALRI.

• INCREASING ACCESS TO TREATMENT

Increasing access to treatment can significantly reduce disease burdens from pneumonia, both by improving quality of clinical care, and by improving access to care through community case management with good quality antibiotics, where community health workers can safely and effectively treat such disorders. Community-based management of neonatal pneumonia resulted in a 42 per cent reduction in pneumonia-specific mortality.⁷⁵ In Ulaanbaatar, delay in seeking medical care for ALRI was associated with younger maternal age: odds ratio (95 per cent confidence interval) 3.8 (1.2–11.6); single child families: 3.8 (1.2–11.61); an absent father: 4.1 (1.2–14.4); and living more than 1 km from a clinic: 3.5 (1.2–10.2).⁷⁶ Further, as mentioned above, good antenatal practices are associated with

decreased odds of death from ALRI.⁷⁷

• REDUCING EXPOSURE TO TOBACCO SMOKE

Sixty-four percent of Mongolians aged 15–49 years old regularly smoke.⁷⁸ This worrying figure represents an aggravating factor to indoor pollution and toxic effects on children. Parental smoking increases the risk of lower respiratory illness in children during the first three years of life (odds ratio: 1.57 [95 per cent confidence interval: 1.42–1.74]) and increases the risk of asthma, recurrent episodes of wheeze and bronchitis.⁷⁹ The risk is increased for maternal smoking, as opposed to that of other family members (odds ratio: 1.72 [95 per cent confidence interval: 1.55–1.91]), but exposure to smoking by other household members is a cause of acute chest illness in young children.⁸⁰ Passive exposure in the postnatal period has less effect on lung function than in utero exposure.⁸¹

Estimated exposures in the population in Ulaanbaatar indicate that environmental tobacco smoke in homes contributes 21 per cent of annual average exposure.⁸² Reducing tobacco smoke exposure at home is important, first because it directly contributes to air pollution-related disease outcomes; and second, because it increases the effectiveness of other air pollution interventions, as it shifts the exposure-response to a steeper part of the curvilinear exposure-response curve. Thus, the incremental health benefit of other air pollution interventions is increased for each microgram per cubic meter reduction in personal exposure.

In Mongolia, tobacco control was addressed by the Tobacco Control Law 2005, along with major changes in 2012 that banned smoking in all public areas to protect the population from the consequences of passive smoking, in compliance with the WHO Framework Convention on Tobacco Control.⁸³ However, smoking has not been

⁷¹ J. R. Groothuis et al., 'Prophylactic Administration of Respiratory Syncytial Virus Immune Globulin to High-Risk Infants and Young Children', *New England Journal of Medicine*, 1993, 329, (21), pp. 1524–1530.

⁷² S. Johnson et al., 'Development of a Humanized Monoclonal Antibody (MEDI-493) with Potent in Vitro and in Vivo Activity against Respiratory Syncytial Virus', *Journal of Infectious Diseases*, 1997, 176, (5), pp. 1215–1224.

⁷³ E. A. Simoes, 'Immunoprophylaxis of Respiratory Syncytial Virus: Global Experience', *Respiratory Research*, 2002, 3 Suppl 1, S26–33.

⁷⁴ Walker et al., op.cit.

⁷⁵ Z. A. Bhutta et al., 'Management of Newborn Infections in Primary Care Settings: A Review of the Evidence and Implications for Policy?', *Pediatric Infectious Disease Journal*, 2009, 28, (1), S22–S30.

⁷⁶ N. Gombojav et al., 'The Effects of Social Variables on Symptom Recognition and Medical Care Seeking Behaviour for Acute Respiratory Infections in Infants in Urban Mongolia', *Archives of Disease in Childhood*, 2009, 94, (11), pp. 849–854.

⁷⁷ Sonogo et al., op.cit.

⁷⁸ Social Indicator Sampling Survey, (SISS), 2013

⁷⁹ D. G. Cook and D. P. Strachan, 'Summary of Effects of Parental Smoking on the Respiratory Health of Children and Implications for Research', *Thorax*, 1999, 54, (4), pp. 357–366

⁸⁰ Ibid.

⁸¹ Greenough, op.cit.

⁸² Ochir et al., op.cit.

⁸³ O. Chimeddamba et al., 'Noncommunicable Disease Prevention and Control in Mongolia: A Policy Analysis', *BMC Public Health*, 2015, p. 15.



addressed in private homes.

Education and awareness campaigns about the hazards associated with smoking at home are recommended to reduce health burdens associated with cigarette smoke. Tobacco cessation programs would also help reach targets agreed by United Nations member states of a 25 per cent reduction in premature cardiovascular disease by 2025.⁸⁴ In addition, increased recognition of chronic respiratory diseases as non-communicable diseases is recommended. The National Program on Integrated Prevention and Control of Non-Communicable Diseases 2006–2013, issued by the Government of Mongolia in 2005, covered prevention and control of major non-communicable diseases, including cardiovascular disease, cancer and diabetes mellitus, but not chronic respiratory diseases.⁸⁵

2.3.5 MITIGATING OTHER CHILD-SPECIFIC RISK FACTORS

Risk factors for pneumonia as an ALRI in infants were air pollution, tobacco smoke exposure, lack of exclusive breastfeeding from 0 to 5 months

⁸⁴ G. A. Roth et al., 'Estimates of Global and Regional Premature Cardiovascular Mortality in 2025', *Circulation*, 2015, 132, (13), pp. 1270–1282.

⁸⁵ Chimeddamba et al., *op.cit.*

(which increased from partial to not breastfed), low birth weight, stunting, wasting and zinc deficiency.⁸⁶ Similar risk factors impact on lung development, in addition to prenatal maternal smoking.

• CHILD NUTRITION

The epidemiology of childhood diarrhea and pneumonia overlap, which might be partly because of shared risk factors, such as undernutrition and suboptimal breastfeeding.⁸⁷ Adjusting for age, gender, and history of wheezing, vitamin D halved the risk of ALRIs in winter among Mongolian children with vitamin D deficiency (rate ratio: 0.50 [95 per cent confidence interval: 0.28–0.88]).⁸⁸

• BREASTFEEDING

The fifth WHO global nutrition target for 2025 is to increase to at least 50 per cent the rate of exclusive breastfeeding in the first six months.⁸⁹ Suboptimal breastfeeding is a risk factor for ALRI. Maternal IgG antibodies against RSV cross the placenta and in sufficient levels help to protect the infant from severe infection.

⁸⁶ Chopra et al., *op.cit.*

⁸⁷ Walker et al., *op.cit.*

⁸⁸ C. A. Camargo, Jr. et al., 'Randomized Trial of Vitamin D Supplementation and Risk of Acute Respiratory Infection in Mongolia', *Pediatrics*, 2012, 130, (3), e561–7.

⁸⁹ WHO, *Global Nutrition Targets 2025: Breastfeeding Policy Brief*, 2014, WHO/NMH/NHD/14.7.

Education and awareness campaigns targeted toward pregnant women may reduce the impacts of ALRI, especially when combined with the prevention of aggressive marketing of breast milk substitutes. Counselling mothers during pregnancy, immediately after childbirth and during the neonatal period has significant positive effects on rates of exclusive breastfeeding. Exclusive breastfeeding has the single largest potential impact on child mortality of any preventive intervention feasible for delivery at high coverage in low-income settings, and is a primary intervention for the prevention of pneumonia.⁹⁰

• LOW BIRTH WEIGHT

Low birth weight is a major predictor of perinatal mortality and morbidity, and also increases the risk for non-communicable diseases such as diabetes and cardiovascular disease later in life.⁹¹ There is evidence suggesting causality between air pollution and low birth weight, but effect sizes, the most vulnerable period of pregnancy and the role of different pollutants still need to be clarified.⁹² Current evidence implicates the role of multiple pollutants during multiple time windows of vulnerability.⁹³ Low birth weight is implicated in ALRI, however, and thus interventions to reduce low birth weight will reduce disease burdens from ALRI, and other air pollution-related diseases later in life. Perinatal outcomes are important markers of future child and adult health.⁹⁴

The effect of air pollutants on birth weight may be through their impact on preterm birth and/or on fetal growth. Most studies acknowledge the potentially different etiology of growth restriction as compared to preterm birth. A growing body of research has linked elevated air pollutant exposures to preterm birth and pre-eclampsia

at pollution levels typical of many US cities.⁹⁵ Preterm birth is associated with 70 per cent of neonatal deaths and up to 75 per cent of neonatal morbidity.⁹⁶ Studies conducted throughout North and South America, China, Korea, Taiwan, the Czech Republic, and Australia have reported an association between increased concentrations of ambient air pollution during pregnancy and suboptimal fetal growth.⁹⁷

3. COST AND EFFECTIVENESS OF INTERVENTIONS

Table 3 shows the estimated relative costs and impacts of interventions to reduce air pollution-related disease in children living in Ulaanbaatar, along with the basis for the impact assessment.

Interventions in prenatal care and the first year of life have the potential for high impact as they are targeted directly at reducing childhood pneumonia. Low-cost interventions such as reducing maternal and secondhand tobacco smoke exposure can have a medium impact on disease outcomes, but compliance can be difficult. Highly effective interventions exist which are more costly, such as 13-valent pneumococcal vaccines and antibiotic treatment in community care settings.

As of October 2015, the 13-valent pneumococcal vaccine costs US\$117, according to the US Center for Disease Control.⁹⁸ Treatment costs for pneumonia in Vietnam ranged from US\$34 to \$50 for children less than 5 months old.⁹⁹ Although treatment costs may vary between countries based on healthcare structure, these estimates provide an approximate metric to assess the relative cost of the intervention. Reducing the high level of inappropriate prescribing for pneumonia in Mongolia (56.6 per cent in children) has the potential to improve disease outcomes significantly.¹⁰⁰

⁹⁰ G. Jones, 'How Many Child Deaths Can We Prevent this Year?', *Lancet*, 2003, 362, (9377), pp. 65–71

⁹¹ WHO, *Global Nutrition Targets 2025: Low Birth Weight Policy Brief*, 2014, WHO/NMH/NHD/14.5.

⁹² Šrám, R.J.; Binková, B.; Dejmek, J.; Bobak, M., *Ambient Air Pollution and Pregnancy Outcomes: A Review of the Literature*, *Environmental Health Perspectives*, 2005, 113, (4), 375–382.

⁹³ C. A. Hansen, A. G. Barnett, and G. Pritchard, 'The Effect of Ambient Air Pollution During Early Pregnancy on Fetal Ultrasonic Measurements During Mid-Pregnancy', *Environmental Health Perspectives*, 2008, 116, (3), 362.

⁹⁴ T. J. Woodruff et al., 'Methodological Issues in Studies of Air Pollution and Reproductive Health', *Environmental Research*, 2009, 109, (3), 311–20.

⁹⁵ J. Wu et al., 'Association between Local Traffic-Generated Air Pollution and Preeclampsia and Preterm Delivery in the South Coast Air Basin of California', 2009.

⁹⁶ J. R. G. Challis et al., 'Understanding Preterm Labor', *Annals of the New York Academy of Sciences*, 2001, 943, (1), 225–234.

⁹⁷ Hansen et al., op.cit.

⁹⁸ <http://www.cdc.gov/vaccines/programs/vfc/awardees/vaccine-management/price-list/>.

⁹⁹ D. D. Anh et al., 'Treatment Costs of Pneumonia, Meningitis, Sepsis, and Other Diseases among Hospitalized Children in Viet Nam', *Journal of Health, Population, and Nutrition*, 2010, 28, (5), 436–442.

¹⁰⁰ G. Dorj et al., 'An Evaluation of Prescribing Practices for Community-acquired Pneumonia (CAP) in Mongolia', *BMC Health Services Research*, 2013, 13, 379.

Exclusive breastfeeding for the first six months in Ulaanbaatar dropped from nearly 60 per cent of children in 2010 to 47 per cent by 2013, largely due to the lack of support from families and workplaces, heavy advertisement of breast milk substitutes, and poverty, which forces mothers to go back to work soon after giving birth.¹⁰¹ The costs of exclusive breastfeeding are relatively low, but it is a primary intervention for pneumonia and a wider range of childhood diseases, and thus has a medium impact and should remain a priority.

Prevalence of undernutrition in Ulaanbaatar is approximately 1 per cent of the population,¹⁰² with severe wasting in children under 5 approximately 0.4 per cent in 2013.¹⁰³ However, the impacts of undernutrition, both on lung development and increased odds of death from pneumonia, are significant. Interventions on nutrition are likely to be of medium cost but with relatively low impact due to the low prevalence of undernutrition.

In addition to these interventions, fuel used for heating in primary care buildings and community care centers should be evaluated, as these are primary targets for switching to cleaner fuels to reduce the impacts of air pollution in children who are already sick. Since the proportion of the population in primary care centers is low and it is not certain what fraction of their exposure would be contributed by these heating sources, the estimation of impact is difficult. Children who are already sick are likely to be more susceptible to the impacts of air pollution, in a similar manner to tobacco smoke, and intervention may reduce mortality in those with severe pneumonia. However, due to these uncertainties, the impact is classified as relatively low.

WHO has recently summarized the effect of interventions in Europe and North America to reduce the health impacts of domestic heating with wood and coal.¹⁰⁴ Although the document does not refer to the specific fuel use and environmental conditions of Ulaanbaatar, it provides a useful

background to the efficacy of different options in homes. In Ulaanbaatar, the intervention with the largest impact in homes will be shifting to cleaner fuels, as that will address both indoor and outdoor exposures, and is a long-term solution to the health impacts of air pollution across all age groups. While costs are substantial, the cost of inaction by 2024 would be over US\$140 million per year in DALYs based on the 2012 GDP per capita.¹⁰⁵

Environmental tobacco smoke exposure at home contributed approximately 20 per cent of annual average population exposures.¹⁰⁶ Interventions to reduce exposures are relatively low cost, but have a significant impact. As with prenatal tobacco smoke exposure, however, compliance can be difficult.

Insulation and vestibules are also relatively low cost, with subsidies being the principal method to promote them. Since heating stoves are vented outdoors, the impact of vestibules and insulation may be significant in decreasing the penetration of outdoor air indoors. Preliminary measurements indicate a reduction in air exchange of 40 per cent as a result of penetration barrier layers and insulation in *gers*.¹⁰⁷ Vestibules on houses would also be appropriate both from an energy-efficiency standpoint, and to reduce air pollution infiltration.

As a temporary course of action until the population could be shifted to cleaner fuels, measures such as mechanical air filtration units could be promoted as a component of maternal and child care programs during the first year of life. Since indoor air pollution contributed an estimated 72 per cent of annual average exposures,¹⁰⁸ and a greater proportion for children below the age of 1 who are, for the most part, indoors at home, these filtration units could significantly reduce exposures and health impacts. Such measures, however, should not be viewed as long-term solutions because of air pollution impacts in older children and the rest of the population, which can only really be addressed through a transition to cleaner fuels.

¹⁰¹ http://www.unicef.org/mongolia/2145_22874.html.

¹⁰² <http://knoema.com/FAOFSDD2012/fao-food-security-data-june-2012?tsid=1148880>.

¹⁰³ World Health Organization, Global Database on Child Growth and Malnutrition.

¹⁰⁴ WHO Europe 2015. Residential heating with wood and coal: health impacts and policy options in Europe and North America. ISBN 978-92-890-5076-0

¹⁰⁵ Ochir et al., op.cit.

¹⁰⁶ Ibid.

¹⁰⁷ Building Energy Efficiency Center of the Mongolian University of Science and Technology.

¹⁰⁸ Ochir et al., op.cit.

In schools, boilers that use significant amounts of coal and emit directly into the environment where children spend a large amount of time are a primary target for replacement with gas boilers. Similarly, modern schools with HVAC units can be equipped with induct HEPA filtration, which is low cost but could significantly reduce indoor air concentrations.

In Helsinki, Finland, which has a similar climate, HVAC filtration in workplaces would result in a 27 per cent reduction in annual average population exposures.¹⁰⁹ Although schoolchildren in Mongolia spend 5–6 hours per day in schools, the exposure reductions are likely to be substantial for these age groups. Interventions can also be directed as advisories for children to play indoors at school when air pollution concentrations are high, although the amount of time spent playing outdoors at school is small, and thus the resultant exposure reduction is also likely to be relatively small.

Table 3. Impacts of interventions to reduce air pollution-related disease in Ulaanbaatar

Intervention	Cost	Impact	Summary of effectiveness
Prenatal care and first year of life			
• Tobacco smoke exposure	Low	Medium	• Increased odds of death from ALRI 1.52 (1.20–1.93) for secondhand smoke
• Pneumococcal vaccine	Medium	Very high	• 29% reduction in radiologically confirmed pneumonia; 18% reduction in pneumonia mortality
• Antibiotics	Medium	Very high	• 25% reduction in all-cause mortality; 42% reduction in neonatal pneumonia mortality
• Exclusive breastfeeding	Low	Medium	• Inadequate breastfeeding practices 1.79 (1.18–2.70)
• Nutrition	Medium	Medium	• Increased odds of death from ALRI 4.27 (3.47–5.25) for severe malnutrition. Severe prenatal and postnatal malnutrition in animals has a significant effect on lung development
• Heating fuel in primary care centers	Low	Low	• Not measured but impacts expected to be somewhat low as patients already ill
Home environment			
• Switch to clean fuels	High	Very high	• 27% reduction in population-attributable fraction of ALRI due to air pollution
• Tobacco smoke exposure	Low	High	• Odds ratios of 1.2–1.6 for respiratory illnesses for either parent smoking
• Insulation and vestibules	Low	High	• Increased insulation and barrier sheets reduced air exchange rates by 40% in <i>gers</i>
• Air filters as part of perinatal care programs	Medium	High	• May significantly reduce exposures in neonates
School environment			
• Replace heat-only boilers with gas-fired boilers	Medium	Medium	• Not measured but impacts expected to be moderate due to proximity to schools and playgrounds
• Filtration in air ducts/ HVAC systems where installed	Low	Medium	• 27% reduction in population exposures in Helsinki
• Exercise advisories for high pollutant episodes	Low	Low	• Impacts expected to be low as a relatively small amount of time spent playing outdoors

¹⁰⁹ Hänninen et al., op.cit.

4. IMPROVEMENTS IN LEGAL AND REGULATORY FRAMEWORKS

Appendix 3 lists the current policies that address air pollution in Ulaanbaatar. Although there has been considerable activity at the government level in relation to energy consumption and use, including subsidies for different fuel types, a greater coherence of policies across sectors in relation to air pollution could be achieved. For example, subsidies for raw coal purchasing and shifts from one coal type to another should be better coordinated with policies to address air pollution; and subsidies should not be proposed that result in higher air pollution emissions in the capital. Further, these subsidies should be evaluated in comparison to investment in cleaner-burning alternatives considering the potential health and economic impacts from air pollution on the population. Thus policies relating to energy use and consumption should reflect overall policies to reduce air pollution in the city.

There has also been considerable regulatory activity within the last few years, including the publication of standards and technical requirements for emissions from a variety of air pollution sources; however, the regulatory frameworks and resources to support these regulations have lagged behind. For example, the departments responsible for compliance with emissions standards often lack the equipment and technical expertise to monitor emissions adequately, without which standards cannot be enforced as there is little evidence of violation of standards. In addition, without a clear and effective sanctionary system brought by courts or legal institutions that are perceived to be fully transparent and independent, there is no incentive to comply with standards. In summary, therefore, establishing an effective regulatory framework is critical in achieving the air pollution reductions that are needed to protect health, but this comes at a cost, as long-term investment in human resources and equipment are required for it to be effective.

Since most exposure to air pollution occurs indoors, consideration should be given to whether regulating ambient air pollution is sufficient, or whether some kind of authority over indoor air is needed, perhaps via appliance standards or

building codes. In particular, this relates to the permeability of building envelopes (e.g. external walls and roofs), insulation standards, vestibules and energy-efficiency measures. Currently there is little standardization in building construction codes for houses built in ger districts, yet poor building construction leaves a legacy of increased energy consumption and poor emissions for many years due to the relatively long operational lifetime of houses.

While there have been programs for energy-efficient homes, these were marketed as entire homes rather than as construction guidelines and standards. Permeability standards for ger covering also provide an energy benefit through reduced coal consumption, but when combined with impermeable barriers and vestibules may significantly reduce indoor air pollution concentrations as well. Similarly, continued tightening of standards for residential combustion appliances is recommended, especially emissions and venting requirements for stoves. California, largely through the efforts of the California Energy Commission, has been quite successful with energy efficiency standards for newly constructed residential and non-residential buildings.¹¹⁰ Assembly Bill 758 (Skinner, Chapter 470, Statutes 2009) requires the Energy Commission, in collaboration with the California Public Utilities Commission and stakeholders, to develop a comprehensive program to achieve greater energy efficiency in the state's existing buildings.¹¹¹ In addition, they have used a variety of incentive-based approaches to improve the energy efficiency of residential appliances, such as the federal State Energy Efficient Appliance Rebate Program administered by the US Department of Energy.¹¹² Rebates were offered for the following appliances: washing machines, refrigerators, room air conditioners, dishwashers, freezers, water heaters, and HVAC units. The California Energy Commission also approves plans for the California Clean Energy Jobs Act (Proposition 39), which provides funding to improve energy efficiency and expand clean energy generation in schools.

¹¹⁰ <http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMFREV2.pdf>.

¹¹¹ <http://www.energy.ca.gov/ab758/>.

¹¹² <http://www.energy.ca.gov/2009publications/CEC-400-2009-025/CEC-400-2009-025-CMFREV4.PDF>



5. AWARENESS, CAPACITY BUILDING AND PROMOTION OF GOOD PRACTICES

Awareness and capacity building have been critical components of successful air pollution reduction strategies in industrialized nations, both in driving the population's understanding of the impacts of air pollution on health, thus ensuring that it is on the political agenda; and also in making changes at the household level. Developing awareness on the health impacts of air pollution also aims to build political commitment at the ministerial level to introduce interventions, policies and regulatory frameworks that result in sustained emission reductions. Political commitment is also required to ensure sufficient resources are allocated for research into the health impacts of air pollution, as well as research to evaluate the impacts of policies on air quality, and independent monitoring of the effectiveness of interventions.

In addition to public awareness, information-sharing between ministries is needed, as well as with non-governmental organizations. While some efforts have been made on websites to

disseminate air quality information and background documents, central information-sharing hubs can play a critical role in building awareness. Similarly, information on emissions standards and regulations should be freely accessible to the general public.

Research into environmental health impacts is a necessary component of capacity building. Although well supported previously, the Mongolian Clean Air Foundation's budget for research was completely cut as economic projections fell and with other national budget cuts. Combined with the difficulty for researchers to easily obtain the equipment and consumables needed to conduct research studies, this severely limits the capacity of the research community to improve the quality of information about health impacts as a result of air pollution.

A master plan is needed to address the environmental consequences of economic development, with a predictable financial basis not subject to changes in political situation. This could be developed in a manner similar to the way in which UNESCO collaborated with the

Mongolian Academy of Sciences and with various ministries to develop a Science and Technology Master Plan (2007–2020) to encourage economic development by promoting national systems of innovation. Although top Mongolian students attend universities abroad for advanced training in environmental health research, there is a need to build local capacity. For example, Mongolia and Germany agreed to set up a mining academy for joint research, workshops and advanced training.¹¹³ Similar initiatives are needed to address environmental health issues to build on the expertise of trained staff in Mongolian universities.

Recognizing and rewarding good practice are integral strategies in reducing health impacts from air pollution. For example in 2011, as part of the Sustainable City Awards, the City of London in association with Environmental Protection UK and the Environment Research Group at King's College London, introduced a sustainable city award to recognize and reward UK organizations that have been working on innovative measures to reduce emissions and help improve local air quality. Similar measures in Mongolia would both increase general awareness and also reward good practice in Ulaanbaatar.

¹¹³ A.J. Minchener, op. cit.

PART 3: CONCLUSIONS AND RECOMMENDATIONS



CONCLUSIONS

Giving adequate policy priority to air pollution and its impact on children's health would not only avert children and adult mortality significantly, but would also raise Mongolia's performance vis-a-vis international commitments, starting with the Sustainable Development Goals, as defined in Transforming Our World – the 2030 Agenda for Sustainable Development.¹¹⁴

The interventions outlined in this paper would directly contribute to achieving the air pollution-related components of a number of targets. This would include:

- target 3.2 to end preventable deaths of newborns and children under 5 years of age to at least as low as 12 per 1,000 live births and under-five mortality to at least as low as 25 per 1,000 live births;
- target 3.8 to achieve access to safe, effective, quality and affordable vaccines for all;
- target 3.9 to substantially reduce the number of deaths and illnesses from air contamination;
- target 3.10 to strengthen implementation of the WHO Framework Convention on Tobacco Control;
- targets 7.1 and 7.3 to ensure universal access to affordable, reliable and modern energy services and double the global rate of improvement in energy efficiency;
- target 11.6 to reduce the adverse per capita environmental impact of cities by paying special attention to air quality

In particular, at the conclusion of this report, it is possible to summarize a number of points and recommendations for consideration of Mongolian policy makers and national and international development organizations and civil society.

- Although the Mongolian Government has implemented a number of substantial measures to address air pollution in the last five years, Ulaanbaatar still has some of the worst winter outdoor air pollution in the world, which is set to increase slowly over the next 10 years, with

growing health impacts on the population, unless major new initiatives are undertaken.

- Exposures to air pollution in children cause a large percentage of these impacts, resulting in deaths from pneumonia in young infants, and lung damage that affects the health and well-being of children throughout the rest of their lives. The combination of short and long term health impact on children, makes air pollution an issue requiring immediate and highest policy attention.
- While there is general acknowledgement of the need to switch to clean fuels, a priority is to increase overall awareness of the economic benefits of investing in intervention strategies quickly rather than more gradually.
- Increased recognition that indoor environments dominate exposures to air pollution will direct interventions to reduce air pollution-related disease in the three principal environments in which children are exposed: during prenatal care and the first year of life, indoors at home, and indoors at school.
- Coordination and communication between ministries and with international agencies will become increasingly important, particularly in relation to building codes, energy efficiency, energy subsidies and new technologies.
- Coordinated action requires a strategic road map of how to reduce air pollution exposures in line with WHO air quality guidelines, and adequate national budget to develop the capacity to achieve these goals.

¹¹⁴ <https://sustainabledevelopment.un.org/?menu=1300>.

RECOMMENDATIONS

In close collaboration with Mongolia's Public Health Institute, Ministry of Health and Sports, and Ministry of Environment and Green Development, UNICEF organised an international expert consultation during 25-26 January 2016 with high level international and national experts to discuss scientific evidence and foster a policy discussion. The expert consultation provided an opportunity to present the analysis contained in this report, making a case for urgent actions to mitigate the effects of air pollution on children demonstrating its life threatening long-term effects. London's School of Hygiene and Tropical Medicine, University of California, Los Angeles Children's Hospital, Simon Fraser University, Washington University in St. Louis were among the scientific institutions represented.

As an outcome of the Expert Consultation, a set of recommendations were produced and officially presented to the Mongolian Government and Parliament. These recommendations are herein reproduced as a platform that also summarized the policy direction that UNICEF aims at supporting, with particular reference to child-related aspects.



**The recommendations from the International Conference on
“Understanding and Addressing the Impact of Air Pollution on Child Health in Mongolia”
organized under the auspices of the Speaker of the Parliament of Mongolia
26 January 2016**

The International Conference on “Understanding and Addressing the Impact of Air Pollution on Child Health in Mongolia” was held from 25 to 26 January, 2016 in Ulaanbaatar, Mongolia. The Conference aimed at presenting scientific findings from studies on the reduction of air pollution impact on children's health, as well as an opportunity to learn from international best practices and agree on recommendations for Mongolia. Furthermore, the conference incorporated a consultative workshop with all stakeholders representing all concerned Ministries, at central and capital city level, civil society, academia and development partners. This discussion created an opportunity for inclusive dialogue on policy recommendations to reduce air pollution impact on children's health herewith presented for adoption at highest political level.

The evidence presented at the conference is clear: air pollution imposes a serious health burden in children in UB, including reduced fetal growth, preterm birth, pneumonia, and reduced lung function leading to acute and chronic respiratory diseases. Actions should be taken urgently, starting from children, and air pollution should be identified as one of Mongolia's immediate development priorities with key actions, budget and accountabilities.

The situation requires that coal combustion in residential areas is stopped within the next 4 years.

Based on the research presented on health effects of air pollution in children and the consultative dialogue and comments from stakeholders, the Conference has issued the following recommendations for different sectors:

1.To the Parliament of Mongolia

1.1. Prioritize budget to accelerate short and long term measures to address air pollution and health impacts, in particular on children that should be considered as a priority group because of their vulnerability. This includes

- Economic modelling for effective green energy alternatives.
- Adopt a budget for the Clean Air Action Plan.

2. To the Government of Mongolia

2.1. Empower the National Committee on Reduction of Air Pollution with a clear mandate, regular meetings, targets, responsibility to coordinate all stakeholders and report regularly.

2.2. Develop the multisectoral Clean Air Action Plan to stop coal combustion in residential areas within 4 years with proposed budget.

2.3. Implement the most cost effective clean energy option(s).

2.4. Develop rewards and incentives for good practices targeting individual households, local governments (khoroo or sub khoroo), and private sector.

3.To the central public administrative authorities:

3.1. Ministry of Health and Sports:

3.1.1. Introduce implementation of the pneumococcal vaccine, starting in the highest polluted areas of UB and scaling nationwide.

- 3.1.2. Eliminate tobacco smoking in homes and cars with children and implement enforcing measures.
- 3.1.3. Implement childhood pneumonia management in accordance with GAPPD and the updated WHO IMCI guidelines.
- 3.1.4. Include HEPA filter in prenatal care package.
- 3.1.5. Regular surveillance of adolescent and adult population for acute and chronic respiratory diseases resulting from early and prolonged exposure to air pollution in childhood.
- 3.1.6. Establish a cohort for disease surveillance monitoring and research to investigate long term health impacts in the population as result of chronic exposure to air pollution
- 3.1.7. Coordinate with Ministry of Environment, Green Development and Tourism to develop an early warning advisory system for communication of high air pollution periods to *ger* residents

3.2.Ministry of Environment, Green Development and Tourism:

- 3.2.1. Coordinate with Ministry of Health and Sports to develop an advisory system for communication of high air pollution periods to *ger* residents
- 3.2.2. Coordinate with Ministry of Energy to evaluate existing energy policies in relation to air pollution.
- 3.2.3. Coordinate with Ministry of Energy to undertake feasibility assessments of all clean energy options for heating in residential areas such as gas (LPG, CNG,LNG, Natural gas, DME), electricity, district heating, renewables

3.3.Ministry of Energy

- 3.3.1.Coordinate with Ministry of Environment, Green development and Tourism to undertake feasibility assessments of all clean energy options for heating in residential areas such as gas (LPG, CNG,LNG, Natural gas, DME), electricity, district heating, renewables.
- 3.3.2. Coordinate with Ministry of Environment, Green development and Tourism to evaluate existing energy policies in relation to air pollution.

3.4.Ministry of Construction and Urban Development:

- 3.4.1. Develop building codes for energy efficiency in residential homes and schools
- 3.4.2. Develop energy efficiency codes for *gers*

3.5. Ministry of Education, Culture and Science:

- 3.5.1. Develop research capacity in universities and institutes to monitor and evaluate impacts of policies and address knowledge gaps.
- 3.5.2. Community engagement and behavioural change education on:
 - Health impacts of air pollution in children
 - Health impacts of smoking and secondary smoke during pregnancy and early childhood
 - Prevention and protection from pneumonia
 - Energy efficient building materials and home construction, use of vestibules and permeability barriers in *gers*
 - Use of HEPA filters during neonatal period to 2 years old

3.6. Aimag and Municipal Governors and the Citizens' Representative Khurals:

- 3.6.1. Coordinate with Government to develop rewards and incentives for good practices targeting individual households, local governments (khoroo or sub khoroo), and private sector.
- 3.6.2. Distribute information on best construction practices for energy efficiency

3.7. Ulaanbaatar City government

- 3.7.1. Coordinate with Government to develop rewards and incentives for good practices targeting individual households, local governments (khoroo or sub khoroo), and private sector.
- 3.7.2. Distribute information on best construction practices for energy efficiency.
- 3.7.3. Coordinate with Ministry of Health and Sports to eliminate tobacco smoking in homes and cars with children.

Appendix 1

Ambient air quality standards in Mongolia: MNS4585:2016

Indicators	Duration	Unit	Permissible limits
Chemical			
PM₁₀	24 hours average Annual average	µg/m ³	100 50
PM_{2.5}	24 hours average Annual average	µg/m ³	50 25
SO₂	20 minutes average 24 hours average Annual average	µg/m ³	450 20 10
CO	20 minutes average 1 hour average 8 hours average	µg/m ³	60,000 30,000 10,000
NO₂	20 minutes average 24 hours average Annual average	µg/m ³	200 50 40
O₃	8 hours average	µg/m ³	100
TSP	30 minutes average 24 hours average Annual average	µg/m ³	500 150 100
Pb	24 hours average Annual average	µg/m ³	1 0.25
Benzo-a-pyrene (C₂₀H₁₂)	24 hours average	µg/m ³	0.001
Physical			
Noise	16 hours average 8 hours average Day time (7am-10pm) Night time (10pm-7am)	 dB	 60 45

Appendix 2

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Appendix 3

Policies that address air pollution in Ulaanbaatar

The National Development Strategy (2007–2021), Mongolia's long-term policy document, states that air pollution is a major issue facing the country.

Under objective 2 of the strategic goal to reduce and eliminate environmental pollution, the document states that the State will support the introduction of new technologies to extract liquid and gas fuel from coal (liquefied natural gas), increase the exploitation of renewable energy, and develop the combined exploitation of solar, wind, and hydraulic energy. Furthermore, under objective 3, the document provides for increasing the government budget for activities aimed at ensuring environmental sustainability and adapting to climate change; and increasing funding for projects and programs aimed at reducing air, water and soil pollution and protecting flora and fauna.

The State Great Khural passed the New Development national mid-term program in 2010. It was approved to be implemented in two stages, and a budget of 1.2 trillion MNT was also approved to implement the sub-program 'Smoke-free Ulaanbaatar'. The Standing Committee of the State Great Khural on Economic Policy was tasked with overseeing implementation of this program.

The Law on Air was passed on 31 March 1995. Its main purpose is to ensure the human right to live in a healthy and safe environment, maintain an ecological balance, protect the atmospheric air in accord with current and future generations' interests, and regulate relations pertaining to its sustainable use. The Law on Reducing Capital City Air Pollution was revised in 2012 to be integrated with the Law on Air and was passed. It included an amendment to transfer the National Committee on Air Pollution Reduction from the President's Office to the Government on 12 December 2013.

The following laws, regulations and standards are being enforced:

- Law on Air (revised), 17 May 2012 (the law was amended on 12 December 2013).

- Law on Air Pollution Fees, 24 June 2010 (the law was amended on 17 May 2012).
- Law on Household and Industrial Waste, 2003.
- Law on Prohibiting Imports and Transboundary Transportation, and Exports of Hazardous Waste, 2000.
- Law on Environmental Impact Assessment, 2012.

Nearly 20 rules and regulations were enforced in 2013, approved by government resolutions and orders of the Minister of Environment and Green Development, following the passage of the Law on Air and the Law on Air Pollution Fees.

Furthermore, activities aimed at reducing air pollution and protecting human health are reflected in the National Program on Environmental Health approved by 2005 Government Resolution No. 245, the State Policy on Ecology approved by 1997 State Great Khural Resolution No. 106, the State Policy on Public Health approved by 2001 State Great Khural Resolution No. 81, the National Program on Climate Change approved by 2011 State Great Khural Resolution No. 2, and the National Program on Healthy Cities, Districts, *Soums*, Workplaces and Schools approved by 2011 State Great Khural Resolution No. 359.

The National Program on Environmental Health (2006–2015) states the following:

- Develop a sub-program on air pollution reduction and undertake intensive measures to reduce air pollution;
- Improve the design of *ger* district households' stoves in urban and settled areas, and manufacture and introduce compressed coal fuel;
- Undertake a series of measures to improve ecological management in urban planning and development;
- Develop and implement plans to create green parks, playgrounds, open spaces, bicycle lanes and paths, and footpaths;
- Create a legal framework for importing and implementing lead-free fuel;
- Take measures to prohibit the traffic of

sub-standard automobiles;

- Support the development of small- and medium-size enterprises that utilize progressive technology and have a less negative effect on human health and the environment;
- Take measures to reduce and refine hazardous waste, smoke and emissions produced by heavy industry, mining, and manufacturing.

The Strategy for Reducing Climate Change, Adapting to Climate Change, and Protecting Public Health was passed by Order No. 404 of the Minister of Health on 6 December 2011, and is currently being implemented.

In addition, National Air Quality Standards of Mongolia were approved by Resolution No. 67 on 20 December 2007, establishing permissible levels of widespread air pollutants of chemical and physical origins in ambient and indoor air in order to provide the Mongolian population with a healthy and safe environment for living, working and studying. These standards have been used since 15 January 2008, in analyzing, assessing and monitoring the quality of ambient and indoor air in urban and settled areas, housing, offices, entertainment venues, service facilities, and during planning and exploitation of civil engineering projects. The standards were developed based on WHO guidance, taking into account harmful levels for people's health.

The following is a list of air quality standards currently enforced in Mongolia.

Basic standards and technical requirements for ambient air quality:

1. MNS4585:2007 Air quality. General technical requirements.
2. MNS5885:2008 Permissible levels of pollutants in the air. General technical requirement.
3. MNS6063:2010 Air quality. Permissible levels of pollutants in ambient air in urban and settled areas.
4. MNS6147:2010 Environmental pollution, controlling and containing pollution. Permissible levels of pesticide residues in the air and soil.

Standards and technical requirements for emissions by air pollution sources:

1. MNS5457:2005 Maximum permissible level of air pollutants in the smoke in heating and household stove chimney flues.
2. MNS5568:2005 Household stoves which use liquefied fuel. General technical requirements.
3. MNS5606-1:2006 Environmental protection. Permissible levels of smoke emissions by diesel-based crematoria.
4. MNS5919:2008 Thermal power stations. Maximum permissible levels of some types of air pollutants in the smoke emitted into the atmosphere during the operation of thermal power stations' steam and water heating furnaces; and methods of measuring the concentration of the pollutants.
5. MNS5013:2009 Petroleum-based motor vehicles. Maximum permissible levels of hazardous substances in exhaust gas; and methods of measuring concentrations of hazardous substances.
6. MNS5014:2009 Diesel-based motor vehicles. Maximum permissible levels of soot in the exhaust gas, and methods of measuring the levels of soot.
7. MNS5216-1:2011 Household stoves. General technical requirements.
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9. MNS6342:2012 Air quality. Maximum permissible levels of some types of air pollutants in the smoke emitted into the atmosphere through the chimneys of hazardous waste incineration furnaces.

International treaties and conventions

Mongolia is party to a number of international treaties on protecting the environment and people's health, including the Stockholm Convention, the Kyoto Protocol, and the Basel Convention.



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Drawings used in the report are selected from a children's drawing competition organized on the occasion of the International Conference on reducing impacts of air pollution on children's health in Ulaanbaatar.

